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SUMMARY

WORKSHOP ON HETEROEPITAXIAL InP SOLAR CELLS

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The workshop considered the following topics.

JUSTIFICATION FOR WORK IN THIS AREA

RESULTS TO DATE

DESIREABLE SUBSTRATE CHARACTERISTICS

REALISTICALLY ACHIEVABLE EFFICIENCIES

THE DISLOCATION PROBLEM

PEELED FILMS

FUTURE RESEARCH POSSIBILITIES

A summary of the workshop discussions follows.

Justification: In a generic sense, the justification for any sort of InP solar cell research applies here; i.e. to take advantage of the inherently high radiation resistance and efficiency of InP solar cells. To be more specific; the approach is justified by its potential for significant cost reduction and the availability of greatly increased cell area afforded by substrates such as Si and Ge. The use of substrates, such as the latter two, would result in increased ruggedness, ease of handling and improved manufacturability. The use of more rugged substrates would lead to a greatly increased capability for cell thinning leading to the desireable feature of reduced array weight.

Results to Date: The highest 1 sun AMO efficiency reported to date was 13.7%.[1,2] This was achieved with a GaAs substrate and $Ga_xIn_{1-x}As$ transition layers. The latter is lattice matched to InP when x=0.47. A similar cell, with an anti-obscuration cell cover achieved an efficiency of 19.9% under 71.8X AMO concentration at 25 °C.[3] Considering multibandgap cells, A three terminal arrangement with an InP top cell and $Ga_{0.47}In_{0.53}As$ bottom cell achieved a combined efficiency of 31.8% at 50X AM1.5 and T=50 °C.[4] In addition, a two terminal multibandgap device with InP top and GaInAsP bottom cell, yielded an AM1.5 (global) efficiency of 14.8%.[5]

Substrate Characteristics: Low cost, light weight, ruggedness and availability in large area were deemed to be desireable substrate characteristics. Ideally, all of these characteristics should be combined with close matching of lattice constant and thermal expansion coeficient to InP. Since the cell is processed at a relatively high temperature, it is also desireable that the substrate thermal expansion coeficient be such that the InP would cool down in compression.

Efficiencies: In theory, AMO efficiencies over 21% are predicted if dislocation densities below 10^5/cm2 are achievable together with surface recombination velocities of 10^5 cm/sec or lower. However, it was concluded that 18% is a realistic near term goal with dislocation densities on the order of $10^6/cm^2$. A far term goal of 20% appears achievable.

Dislocations: The workshop participants considered methods to reduce the harmful effects of dislocations on cell performance. At present, $3X10^7/cm^2$ is the lowest dislocation density reported for a heteroeptiaxial InP cell.[1,2] Obviously, there is room for improvement in this area. Dislocation passivation by hydrogen, which has in the past worked for Si, is a technique which deserves close attention for InP. It was also recommended that more effort be expended on the use of lattice matching transition layers. Aside from these two techniques, there is a scarcity of ideas on how to attack this difficult problem. There is ample room here for creative material science.

Peeled Films: The cell processing would entail epitaxial thin film deposition on an ultra thin release layer deposited on InP. A selective etch separates cell from substrate. The completed cell can be used in a stand alone mode with a glass superstrate or attached to a heterogeneous substrate such as Si. Advantages are decreased dislocation density and reduced cost through substrate reuse. Difficulty in handling is a principal disadvantage.

Future Research Possibilities: It is surprising that no results have been reported using Ge as a substrate. From the viewpoint of ruggedness, price and availability in large areas, it is preferrable to GaAs. In addition, when compared to Si, it has the advantages of a much closer match, to InP, of lattice constant and thermal expansion coefficient. Use of a buffer layer of ZnSe on Ge or Si was also suggested. With regard to choice of cell configuration, one should bear in mind that Ge and Si are n-dopants in InP and GaAs. Hence, one should chose a configuration which avoids the creation of a performance limiting counterdiode. Aside from this caveat, the workshop expressed no preference for either the p/n or n/p configuration nor was any preference expressed for either planar, multibandgap or concentrator cells. With respect to a goal at which to aim for SRV's, 10^4 cm/sec is desireable. With respect to dislocations, $10^6/cm^2$ is a realistic goal, with $10^5/cm^2$ desireable but extremely difficult to achieve. Finally for the EOL efficiency goal, it was decided that 16% would be desireable after 5 years in a mid-altitude orbit.

REFERENCES

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